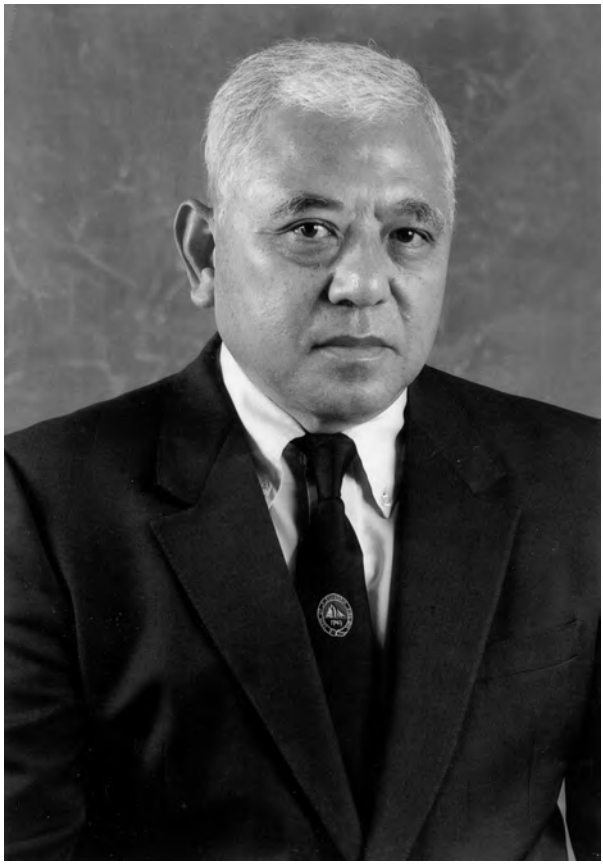

Riki Kobayashi

RIKI KOBAYASHI

1924–2013

Elected in 1995

"For advances in the knowledge and measurement of the thermodynamic and transport properties of natural gas liquids and gas hydrates."

BY GEORGE J. HIRASAKI

RIKI KOBAYASHI, Louis Calder Professor Emeritus in Chemical Engineering at Rice University, died on July 19, 2013. He was known as Riki by his graduate students, although students from Japan respectfully call him "sensei."

Riki was born to Misutaro and Moto Kobayashi on May 13, 1924. Misutaro was a mechanical engineer in Japan who came to San Francisco in 1904. After the earthquake of 1906, Misutaro moved to the Saibara colony in Webster. In 1913 Moto came to America as a "picture bride." Riki's father raised Satsuma oranges in Webster and planted cucumbers between the orange trees. Once when the orange trees froze, the cucumbers saved his business. My father told me that he once visited Riki's father to discuss cucumber culture. Riki told me that our families are related by marriage in Japan. My grandmother's maiden name was Kobayashi, but then Kobayashi is a common family name in Japan.

Riki graduated from Rice University (then known as the Rice Institute) in 1944 with a BS in chemical engineering when he was 19 years old. He graduated with a PhD from the University of Michigan in 1951 and immediately joined the faculty of the Rice Institute. His thesis advisor was Donald Katz. Riki was one of the coauthors with Katz on the *Handbook of Natural Gas Engineering*, published in 1959 (McGraw-Hill). He

was also a coauthor with Rice professor Tom Leland of the chapter on "Thermodynamics" in the *Handbook of Chemical Engineering*, the bible for the chemical engineering profession. Riki coauthored with Kuy Song and Dendy Slone the chapter on "Phase Behavior of Water/Hydrocarbon Systems" in the *Petroleum Production Handbook* (1987), and he coauthored with Patsy Chappelear and Harry Deans the chapter on "Physico-Chemical Measurements by Gas Chromatography" in *Applied Thermodynamics* in 1968. He authored approximately 200 journal articles.

When I was considering Rice for graduate school, my father said to look up one of the Kobayashi boys on the faculty at Rice. I got an appointment with Riki and he told me to come to Rice for my graduate studies. I did not apply elsewhere. I remember Riki as one of the young faculty members who would throw a football with his students.

At that time the Chemical Engineering Department was well known for the "Riki boxes" for measuring thermodynamic and transport properties at cryogenic conditions. These were complex instruments to measure properties of fluids at low temperatures for separation of components of natural gas. The instruments were surrounded by a "box" to hold the refrigeration coolant while making measurements but could be lowered when working on the instrument. The data from this technology are now used to liquefy natural gas for transportation of natural gas from places like the Middle East and Australia to markets in Europe and Asia.

Riki's interest in gas hydrates spanned his entire professional career, beginning with his PhD research and continuing even after he retired. At the time of his PhD research, gas hydrates were known as the ice-like material that would plug up natural gas pipelines. I visited him in the 1980s and he was conducting a graduate seminar on how to produce natural gas from methane hydrate deposits below the permafrost. At that time hardly anyone was thinking about producing natural gas from hydrates. In 2013 Japan did a successful production test of natural gas from marine deposits of methane hydrates off the coast in the deep waters of the Nankai Trough.

Riki was a pioneer in using nuclear magnetic resonance (NMR) to measure the diffusion coefficient of hydrocarbon fluids. In the 1960s he was working on NMR with Raph Dawson and Fouad Khoury. When I joined the faculty in 1993, Riki encouraged me to do NMR research. He gave me piles of literature, dating back to 1948, to get me up to speed on the NMR science. His dream was to discover the unifying connection between viscosity, diffusivity, and thermal conductivity with the NMR T_1 and T_2 relaxation times. He was hoping to use the principle of corresponding states to unify these properties. We were awarded a research grant by the National Science Foundation and Sho-Wei Lo earned her PhD showing that methane in live oil relaxed by the spin-rotation mechanism rather than the dipole-dipole interactions as was commonly assumed at that time. Subsequently, Shell, Schlumberger, and Marathon donated NMR spectrometers to Rice to encourage us to continue the research.

Perhaps more than any other living individual, Professor Kobayashi has provided the engineering database for the natural gas industry. He received the first Donald L. Katz Award from the Gas Processors Association (GPA) in 1985. This award "was initiated to recognize outstanding accomplishments in midstream research and technology, and/or for excellence in engineering education." His work was characterized in a 1987 American Institute of Chemical Engineers (AIChE) symposium in his honor as "one of the century's most prolific and lasting efforts in thermodynamic and transport properties." He had the vision to pioneer (1) the measurement of hydrocarbon vapor–water–gas hydrate equilibrium; (2) the use of gas chromatography to measure vapor-liquid and vapor-solid equilibria, phase transitions, and molecular diffusivity; (3) the use of laser light scattering to measure properties in the critical region; and (4) the use of NMR relaxation measurements to determine the connection between diffusivity and viscosity with NMR relaxation times through the corresponding state principle of thermodynamics. His exceptionally high quality pressure-volume-temperature (PVT), vapor-liquid equilibria (VLE), and viscosity data have become the standard of the

industry for the development of correlations and have found immediate use by industry. His low-temperature VLE data have permitted the design and development of the turbo-expander plant, the most prevalent process in the gas industry. Recent industrial applications of his data include (1) design of CO_2 processing facilities for enhanced oil recovery, (2) design criteria for dehydrating natural gas in North Slope and North Sea production to prevent hydrate formation, and (3) water content criteria for gas transmission in the proposed Alaskan Gas Pipeline.

Riki was elected a member of the National Academy of Engineering in 1995. He was a fellow of AIChE and the American Institute of Chemists and a member of the Academy of Medicine, Engineering and Science of Texas, the Japan Institute of Chemical Engineering, the American Institute of Mining, Metallurgical, and Petroleum Engineers, and the American Chemical Society. He was awarded the Outstanding Engineering Award at Rice University in 1985 and the Albert Einstein Medal from the Russian Academy of Natural Sciences in 2010.

Riki's legacy at Rice University is remembered by the Riki Kobayashi Graduate Fellowship in Chemical Engineering. This is a perpetual fellowship from an endowment raised by Riki's friends, associates, and former students who want to recognize Riki and the impact he had on their lives and careers.

I miss Riki—he was my teacher, fellow professor, and a family friend. He is survived by his wife Lee, two sons, two stepdaughters, and three grandchildren.